In all these cases of auroral displays the inductive effects upon the telegraph wires are very strongly marked; currents of varying intensity and direction flowing unceasingly through these metallic circuits.

The result of observations made in Shetland during the months of September, October, November, and December last year, tend to show that these auroral disturbances attained their maximum effect upon the wires between $8^h 30^m$ and $9^h 30^m$ A.M., and between $8^h 30^m$ and $10^h 30^m$ P.M.; and such is the unstableness of these induced auroral currents, that frequently in five minutes the electromotive force will vary from very much less than that of a Daniell cell to a current of such intensity that a brilliant stream of light will flash across the points of the lightning conductors with sharp detonating reports, the electromotive force of which would be scarcely equalled by 500 Daniell cells.

In January last very curious electrical phenomena were observed at Lerwick through the day-time, in connection with the N.E. gales so prevalent at that period of the year. In Shetland these gales are almost without exception accompanied with very severe hail-storms. The day begins bright and fine, a clear sky, the barometer rapidly rising; low on the horizon may be observed dense and angry-looking clouds. One by one these clouds travel fast towards the zenith, when all at once a fearful gust of wind, accompanied with the most violent hail-storm, will apparently break out of the cloud, and continue for about fifteen minutes. The wind then subsides, and the day appears as fine as before. In half an hour's time a second cloud will have appeared, and there will be a repetition of the temporary tornado and hail-storm. The remarkable circumstance attending these successive storm clouds is that they appear to be a purely electrical phenomenon. The moment that the icy discharge takes place from the cloud with its accompanying "crack" of wind, an induced electrical current appears upon the wire, so strong that it attracts firmly down the armatures of the telegraph Morse apparatus. The moment, however, that the hail ceases, the current passes off, but with this result, that each successive cloud storm appears to induce a current flowing in an opposite direction from the last, that is to say, the currents appear to be (using conventional language) positive and negative in their effects.

That these storms are "electrically excited" there is no disputing, and that they occur during the prevalence of the chief auroral displays is also a matter of observation, but so far their connection with aurora has not been sufficiently determined to permit any opinion to be expressed.

The recent successful completion of the telegraph circuit to Shetland, and the extensions immediately to be carried out one hundred miles farther north, will afford much greater facilities for auroral observation than has hitherto existed. It is also proposed to institute a careful spectroscopical examination of the coloured scintillations; and now that the Meteorological Society are about to establish an observation station in Shetland, there is every prospect of some valuable data being collected on this interesting subject, which may hereafter guide our meteorological students in arriving at some satisfactory conclusion regarding the laws of electrical storms and auroral induction. At present we are only able to record a few carefully observed facts.

THE LIGHT OF JUPITER'S SATELLITES

Ueber die Helligkeitsverhältnisse der Jupiterstrabanten, von Dr. R. Engelmann, Observator der Sternwarte zu Leipzig. (Leipzig; London: Williams and Norgate. 1871.)

OF all the satellite systems which so essentially enrich the retinue of the sun, none, when we have left our own moon behind us, promises such a reward for investigation as that of the planet Jupiter. The remoter ones may be, and probably are, intrinsically of a more remarkable character, but they are, and ever will remain to a great extent, beyond our reach; while the attendants of the largest among the planets are numerous enough to interest by individual peculiarities, which their comparative proximity enables us to study with advantage. Yet it is readily observable that though ordinary telescopes of good quality would have done much towards elucidating their phenomena, very little progress has been made in the inquiry, especially in this country; and the work now before us is the first attempt to collect and to make serviceable the scattered observations which exist, of which we are sorry to remark how few are due to the astronomers of England.

The especial object of the eminent observer at Leipzig has been not the theory of the motions of these satellites, but simply their physical aspect in regard to the variable light which they have long been known to reflect, and to this investigation the author, notwithstanding constant engagement in important zone observations, has contributed far more than all who have preceded him. The instrument which he employed was the astrophotometer of Zöllner. In this ingenious contrivance, the light of the object to be examined is referred to that of one or more known comparison stars, by means of an artificial star produced by a petroleum flame, adjustable for brightness and colour by a Nicol prism, and a "colorimeter," or revolving wheel of tinted rock-crystal. But in order to eliminate the effect of unequal areas, so as to ascertain, not merely the absolute amount of light reflected, but the "albedo," or reflecting power of each surface, it is, of course, necessary to obtain reliable measures of these minute specks of light; and in order to decide the interesting question whether or not their rotation and revolution are, as with our own satellite, synchronous, their anomalies, or orbital positions relative to their primary, have to be taken into account. All this has been done with most praiseworthy care; the whole is discussed and reduced with scrupulous and exemplary attention to every possible source of accidental error; and the result is given to the eye in several elaborate diagrams. We shall merely specify some of the conclusions, which will be found of considerable interest to astronomers. The absolute brightness was found by the author, as it has been by all previous observers, very variable; and from the irregularity and occasional rapidity of its changes, it becomes impossible to decide, in the case of the three interior satellites, whether the periods of rotation and revolution are identical. This, however, appears to be decidedly the fact with the outermost. Herschel I. had extended the inference to all of them; but such a result could not now be accepted; and it seems probable that the spots which must occasion these variations, and which have been repeatedly noticed when the

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satellite has been on the disc of Jupiter, and by Dawes and Secchi even in other positions, may be of changeable character. At a mean II. is relatively the most, IV. the least luminous. As to their micrometrical measurement, every one who is acquainted with the telescopic aspect of these minute discs will readily comprehend its difficulty. It has, however, been attempted in various ways, but not by the double-image micrometer, which does not seem to have been used; the results, as may be expected, present considerable discrepancies, but the final values obtained by a combination of different methods in the hands of various observers are as follow:—I., 1″·081; II., 0″·910; III., 1″·537; IV., 1″·282; or, in English miles, 2,498, 2,102, 3,551, 2,962, the solar parallax being taken as 8″·90. These values, all things considered, differ so little from those given by Lockyer (Guillemin's "Heavens")—namely, 2,440, 2,192, 3,759, 3,062—that we may consider ourselves possessed of a very fair approximation to their real magnitudes.

As to the "albedo" of their surfaces, I. shows no great variation; it falls, according to Zöllner's estimate of the reflective power of terrestrial materials, between that of marl and white sandstone; II. has the greatest variations of albedo, which at a mean somewhat exceeds that of white sandstone; III., the variations of which are smaller and more regular, comes between marl and quartzose porphyry; IV., which varies least, equals that of moist arable land. It will probably be thought, however, that curious as these comparisons may be, the standards are much too uncertain to give any satisfactory result. As to colour, Dr. Engelmann, after citing the elder Herschel's estimates—I., white; II., white, bluish, and ash-coloured; III., white; IV., dusky, dingy, inclining to orange, reddish, and ruddy—specifies as the determination of other observers: I., yellowish; II., white or yellowish; III., intensely yellow with low powers; IV., in achromatics a distinct dusky blue. (These colour-values at any rate afford no countenance to the common impression that Herschel had a bias for red tints.) To the writer, whether with two achromatics, or a nine-inch silvered mirror, this satellite has always appeared ruddy when its colour has formed the object of notice; in such discrepancies something may be instrumental, something subjective. It is pleasant to see here a very full appreciation of the laborious perseverance and honest accuracy of the labours of Schröter, to whose merit time seems to be doing tardy justice; no notice is taken, however, of the observations of Gruithuisen, who twice appears to have seen spots on III on the background of the sky; nor is reference made to the irregular shape of that satellite remarked by Secchi and his assistant; nor to the apparent discrepancy which has often been noticed between the magnitudes of the satellites and their shadows. Still, the treatise may be considered as very nearly an exhaustive one; and a most important and acceptable contribution to planetary astronomy. It may be added that it contains a very valuable determination of the telescopic magnitude of Jupiter, from the average of eleven observers; the result being, with the double-image micrometer 37″·609 for the equatorial, 35″·236 for the polar diameter; with the wire-micrometer, 38″·312 and 35″·914: the former values, which he seems to prefer, exhibiting a flattening of $\frac{1}{15\cdot82}$.

T. W. WEBB

OUR BOOK SHELF

Transactions of the Geological Society of Glasgow. Vol. III. Supplement. On the Carboniferous Fossils of the West of Scotland: their Vertical Range and Distribution. By John Young, Vice-President. With a General Catalogue of the Fossils and their Mode of Occurrence, and an Index to the Principal Localities. By James Armstrong, Honorary Secretary. (Glasgow, 1871.)

THIS catalogue of fossils will doubtless be of great use not only to local geologists, but to others at a distance, who may desire to compare the treasures of English and Irish Carboniferous strata with what the equivalent beds in Scotland have yielded. So far as they go, the lists appear to be drawn up with considerable care, and Mr. Armstrong is to be congratulated upon the result of what must have been somewhat laborious work. But we are sure he will be the first to admit that much, very much, still remains to be done before the Scottish Carboniferous flora and fauna can be satisfactorily compared with those of other countries. We are constantly being reminded throughout this catalogue that not only in private collections, but also in public museums in the West of Scotland, there are numbers of specimens under almost every class waiting to be identified, amongst which there is every reason to believe that not a few are species new to science. This, it seems, is specially the case with the plants, the rich flora of the Carboniferous period being represented in the catalogue by only ninety species. But Mr. Carruthers, we are told, has several undescribed specimens in hand, of which we shall, no doubt, hear by-and-by. The fishes, it would appear, also need looking after. There are eighty-four species, under forty genera, named in the catalogue; but a large number in various collections have never been correctly identified with described species, and Mr. Young expresses a hope, in which we cordially join, that Prof. Young will be induced to prepare a special catalogue of these and the Reptilia, of which only seven species are given by Mr. Armstrong. The other classes are represented as follows:—Foraminifera, 2 genera, 4 species; Hydrozoa, 1 g. 2 sp.; Zoophyta, 22 g. 59 sp.; Echinodermata, 6 g. 15 sp.; Annelida, 4 g. 7 sp.; Crustacea, 19 g. 71 sp.; Insecta, 2 g. 2 sp.: Polyzoa, 11 g. 36 sp.; Brachiopoda, 15 g. 50 sp.; Lamellibranchiata, 28 g. 127 sp.; Pteropoda, 1 g. 1 sp.; Gasteropoda, 15 g. 75 sp.; Cephalopoda, 6 g. 46 sp. From these numbers it will be seen that the collectors have not been idle, and, no doubt, Mr. Armstrong's catalogue, with its minute index to localities, will be the means of sending many to hunt in quarters which they have not already visited. Let us hope that they will note something of the conditions under which the fossils are distributed, and not content themselves simply by bringing away good bags full. Collectors cannot be too often reminded that it is of more importance, in the interests both of natural history and geology, to know one limited district thoroughly, than to go roving over half a country merely for the purpose of picking up finely preserved specimens. Each should mark out for himself some practicable area, and make it his endeavour to search every bed, even the most unpromising, noting not only the fossils he meets with, but the character of the strata in which they occur. He should also observe what effect a change in the character of a bed has upon the fossils it may happen to contain; whether they increase or decrease in numbers, whether they individually gain in size or become dwarfed, and, should certain species disappear, what others, if any, are substituted for them. It is only by marking carefully such points as these that we can ever hope to acquire an adequate conception of the natural history of the old carboniferous lands and seas. Mr. Young is quite sensible of the shortcomings of the collectors in this matter, and gives them some seasonable advice, which it may be hoped they will take to heart. If collectors paid better heed to these

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